BUILT-IN VEHICLE DIAGNOSTICS SYSTEMS

Russel L. O'Neal and William K. Emerson

Introduction

A major goal of the Army Chief of Staff's transformation effort is to reduce the logistics footprint. The United States can no longer afford the luxury of building up a large stockpile of spare parts, many of which are stored "just in case." Ground forces must have the ability to be quickly deployed into a region and be sustained with minimum support.

Previously, if an electronic component in a vehicle went bad, the entire component was removed and sent to the rear where it was replaced with a spare from the "iron mountain" that was moved in theater to support the deployed force. Usually the nonfunctioning part was repaired and ultimately returned to stock. Often during this process, however, the repair person discovered that the "failed" unit was functioning properly and showed no evidence of failure. Reduction or elimination of these false failures must be accomplished if the Army expects to reduce the number of spare parts transported to an active theater.

One of the best ways to reduce false failure is to improve the on-vehicle system testing capabilities. New systems are being designed with built-in diagnostics as an integral part of the equipment, but what about older systems such as the Abrams tank or the Bradley Fighting Vehicle System (BFVS) that essentially have no on-vehicle fault isolation?

Currently, vehicle line replaceable units (LRUs) are diagnosed using symptom-based technical manual procedures. Test equipment, including a large number of interface boxes, cables, and adapters and their supporting manuals, must be carried to the vehicle being tested, adding to the mass of equipment that must be moved to a theater of operations. Once the test equipment is at the vehicle site, the test procedures are labor-intensive, error-prone, and time-consuming. Additionally, the STE-M1/FVS Test Set currently used (simplified test equipment—M1 Series vehicle and M2/M3 FVS) is becoming obsolete. Newer vehicles such as the Bradley A3 have a system 1553 data bus that is used for built-in test (BIT). The BIT provides fault isolation to an ambiguity group. Additional carry-on test equipment must be used to break the ambiguity and fault-isolate to a single LRU. In both cases, fault isolation testing must be performed while the vehicle is in a nonoperational maintenance mode. Actual testing requires removing the operational cables and connecting the test set cables and adapters to the boxes being tested.

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Diagnostics Solution

A Huntsville, AL, company has developed a way to easily reduce the logistics burden on vehicles. The system, called Sidecar™, provides a comprehensive on-vehicle diagnostics solution consisting of Sidecar modules (either attached to existing boxes or embedded inside redesigned boxes), cables, a host controller, a power supply, and software.

A Sidecar module consists of miniaturized electronic measurement equipment that is permanently installed on a vehicle. These modules are small, easily fitting into the palm of your hand, and even in cramped combat vehicles, can be added in the limited space available. The nonintrusive modules provide measurements on demand from the LRUs via a high-speed serial data bus. They neither stimulate the LRU in any way, nor draw LRU power. Made at the interface test connector so signals are not degraded, measurements are digitized and sent to the host controller.

The host controller provides the command and control for the embedded diagnostic system and may either be embedded in the vehicle, such as on a processor card in an

LRU, or be in carry-on equipment such as a ruggedized laptop computer. Software embedded in the system performs the diagnostic logic unique to each vehicle's subsystem. The embedded processor and software provide the capability of health checks during vehicle operation. A carry-on computer provides full diagnostics and fault isolation capability, and can also provide the latest in interactive electronic technical manuals to direct the testing, troubleshooting, and removal and replacement actions.

Militarized cables, which include the data bus and a power bus and are designed to withstand the vehicle-operating environment, permanently connect the modules. The end link of the cable chain is connected to the host controller, and the system can be used both during vehicle operation and maintenance.

Module Interface

Sidecar modules have one part number and are the same for all installations. Every LRU test connector is different, yet the Sidecar module can interface to the unique test connector using a personality cable that configures the signal lines as necessary. The personality cables and Sidecar modules are permanently installed in the vehicle, providing a significant logistics advantage. A limited number of spare modules can support the entire division because they are interchangeable. If a Sidecar module on a critical LRU is damaged, it can be replaced with one from a noncritical location.

There are several ways to implement Sidecar modules, depending on the requirements of the particular vehicle and the maturity of the LRUs. External Sidecar modules may be used for legacy vehicles where older LRUs are used and the vehicle cabling and space claim are established. The Sidecar module is attached to the generally unused LRU test connector, and the cables are then bundled with the existing vehicle cables.

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In some cases, signals required for complete fault isolation capability may not be available on the test connector but are found on the functional connectors. The Sidecar modules can be added to a T-connector of a functional cable without impacting the vehicle's operational performance.

As these older systems are upgraded, electronic test circuitry can be incorporated into new LRU designs, thus reducing the internal wiring requirements of a test connector. For new designs, the diagnostic data bus can be directly connected to the electronic box.

Where LRUs were designed with spare slots in the backplane, an embedded Sidecar can be installed into a spare slot and the test signals brought through the backplane. For those LRUs without spare backplane slots, a mounting bracket for the Sidecar circuit cards can be added and test signals brought through the LRU harness or a flex cable.

Conclusion

Use of Sidecar in older weapon systems will result in major savings, both in time and hardware repair costs. Permanent installation on the vehicle eliminates the need for special test equipment to be issued, taken to the vehicle, and then returned to storage. In addition, approximately 40 percent of all LRUs removed from a vehicle are damaged as a result of improper use of special test equipment. Removal and installation of vehicle cables and test cables, and manual probing with special equipment during testing, can cause delicate electronic contact pins or pin receptacles to bend or be pushed into cables or boxes. The use of Sidecar eliminates these maintenance-induced faults.

The Sidecar system is currently being installed in the M1A1 Abrams Integrated Management (AIM) upgrade tank and is planned for installation in several other U.S. and foreign vehicles, such as the Egyptian M1A1 AIM tanks, the U.S. M1A1 legacy fleet, and various vehicles being considered for the medium brigade. One program manager estimates that total operations and sustainment cost savings will easily exceed $1 billion thanks to the Sidecar system.

This innovative approach to embedding robust diagnostics systems will reduce the volume of spare parts and test sets required for transport overseas during an operation. By reducing this hardware, the support personnel requirements also decrease. Sidecar is a direct result of the U.S. Army and its contractor partners working together to find low-cost and effective solutions for improving logistics.

RUSSEL L. O'NEAL, a Logistics Management Specialist, is the M1A1 Tank Embedded Diagnostics Integrated Product Team Leader in the Abrams Tank Program Manager's Office, Warren, MI.

WILLIAM K. EMERSON is a Senior Program Manager at PEI Electronics, Huntsville, AL. He is a retired Army lieutenant colonel.